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955 L'Enfant Plaza North, S.W.
Washington, D. C. 20024

date: August 30, 1971

to: Distribution

B71 08043

from: C. Bendersky

subject: Drop Tank Orbiter - Possible Impact on Space Shuttle APU Technology - Case 237

ABSTRACT

NASA is proceeding with the second phase of the auxiliary power unit (APU) technology program which is to support the Space Shuttle. A basic hydrogen-oxygen breadboard system has been selected for experimental demonstrations, and its size is to be compatible with the fully recoverable 2-stage Space Shuttle. NASA is also considering partially recoverable orbiters in which hydrogen or both hydrogen and oxygen are carried in drop tanks. These configurations have smaller APU requirements, and they could require a change in the present APU technology program. During discussions of this topic at Grumman, it was stated that the potential maximum reduction of APU requirements for drop tank orbiters is approximately 30 percent. Considering the limited knowledge of the actual APU requirements, the present programs should continue as planned.

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MEMORANDUM FOR FILE

Previous memoranda[1,2] described the auxiliary power unit (APU)[3] system studies which were performed as a part of the Space Shuttle Technology Program. It was reported that the Lewis Research Center (LeRC) sponsored both AiResearch and Rocketdyne to screen candidate APU systems and execute a preliminary design of a selected APU which would be suitable for both the booster and orbiter of a fully reusable Space Shuttle. Based on a duty cycle provided by NASA, both contractors designed hydrogen-oxygen APU capable of operating between 400 and 33 shaft horsepower using gaseous propellants from the attitude control propulsion system accumulators.

NASA selected the AiResearch concept as the baseline for continuing technology studies and breadboard demonstrations. Technology readiness is planned for June 1973.

Recently a number of promising alternatives to the fully recoverable Space Shuttle have evolved. All are two-stage configurations in which either the orbiter hydrogen alone or both propellants are stored externally to the recoverable orbiter core. The external tanks are separated or dropped after the orbiter reaches orbit. These drop tank orbiter configurations may be launched by existing expendable boosters during early operation in a phased Space Shuttle development program.

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[1] Rocketdyne and AiResearch Space Shuttle APU Studies - Final Review, C. Bendersky, Case 237, B71 08029, August 19, 1971.

[2] AiResearch Space Shuttle APU System Study Review, C. Bendersky, Case 237, B70-10064, October 28, 1970.

[3] The APU has been renamed the flight control power unit (FCPU).

Compared to fully reusable orbiters, drop tank versions have smaller return, or reusable vehicles and provide a higher portion of the overall boost velocity to orbit. The lower staging velocity allows the reusable booster to be smaller and to be designed for much lower thermally induced loads. It follows that the drop tank orbiter configurations require less APU power for both recoverable stages than a fully reusable system. Thus it was judged desirable to quantify the possible difference in APU requirements before going ahead with the APU breadboard program. Grumman, the company that has thus far looked deepest into the drop tank configurations, was visited on July 15 to discuss APU sizing and possible changes in the APU Technology program that might be brought about by the drop tank concept. The following participated in the discussions.

NASA

B. Leefer/RP
J. Malament/MTG
H. Cameron/LeRC

Bellcomm

C. Bendersky

Grumman

J. Caracini/APU
J. Goodwin/Config. & Aero
D. Murphy/Flight Test
G. Mekos/Flight Test
L. Galfano/Flight Test
H. Kaplan/Technology
L. Rothenberg/ACPS

DISCUSSION

Grumman provided some rough estimates of APU requirements for a fully recoverable, hydrogen drop tank orbiter, and a hydrogen-oxygen drop tank orbiter. They estimated that the hydrogen drop tank orbiter would require 15% less power and the hydrogen and oxygen drop tank orbiter, 30% less power than the fully recoverable system. Since the precision in predicting the actual requirements of the yet to be designed real configuration is poor, Grumman stated that the value of the present APU technology program would not be affected by the final choice of orbiter configuration.

The Grumman development philosophy for drop tank orbiter development is as follows. Subsonic, horizontal flight testing is desirable. During this phase, the airbreathing engines will provide control surface power. During all other flight rest phases a fully qualified APU system is desired. The June 1973 technology readiness date should satisfy the program needs.

Grumman was slightly concerned with the present baseline APU propellant acquisition philosophy. At present the APU propellants are stored in common tankage with the ACPS and on-orbit maneuvering system (OMS). The APU propellants are roughly 2-1/2% of the total and are primarily required for flight control after the ACPS and OMS functions are completed and when the tanks are nearly empty. In addition, the required APU propellants are relatively constant from mission-to-mission whereas the OMS loaded propellant may vary. It is possible that the propellant reserves necessary to guarantee sufficient APU supply in all mission modes may be sufficiently large to warrant consideration of separate APU, or possibly APU and ACPS, tankage. This subject will be studied further by Grumman.

In conclusion, it is not apparent that selection of a drop tank orbiter will change the value of the presently planned APU technology program, so it should proceed as planned.

C. Bendersky

1013-CB-ajj

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